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AGUE

OR

INTERMITTENT FEVER.

BY

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1897.

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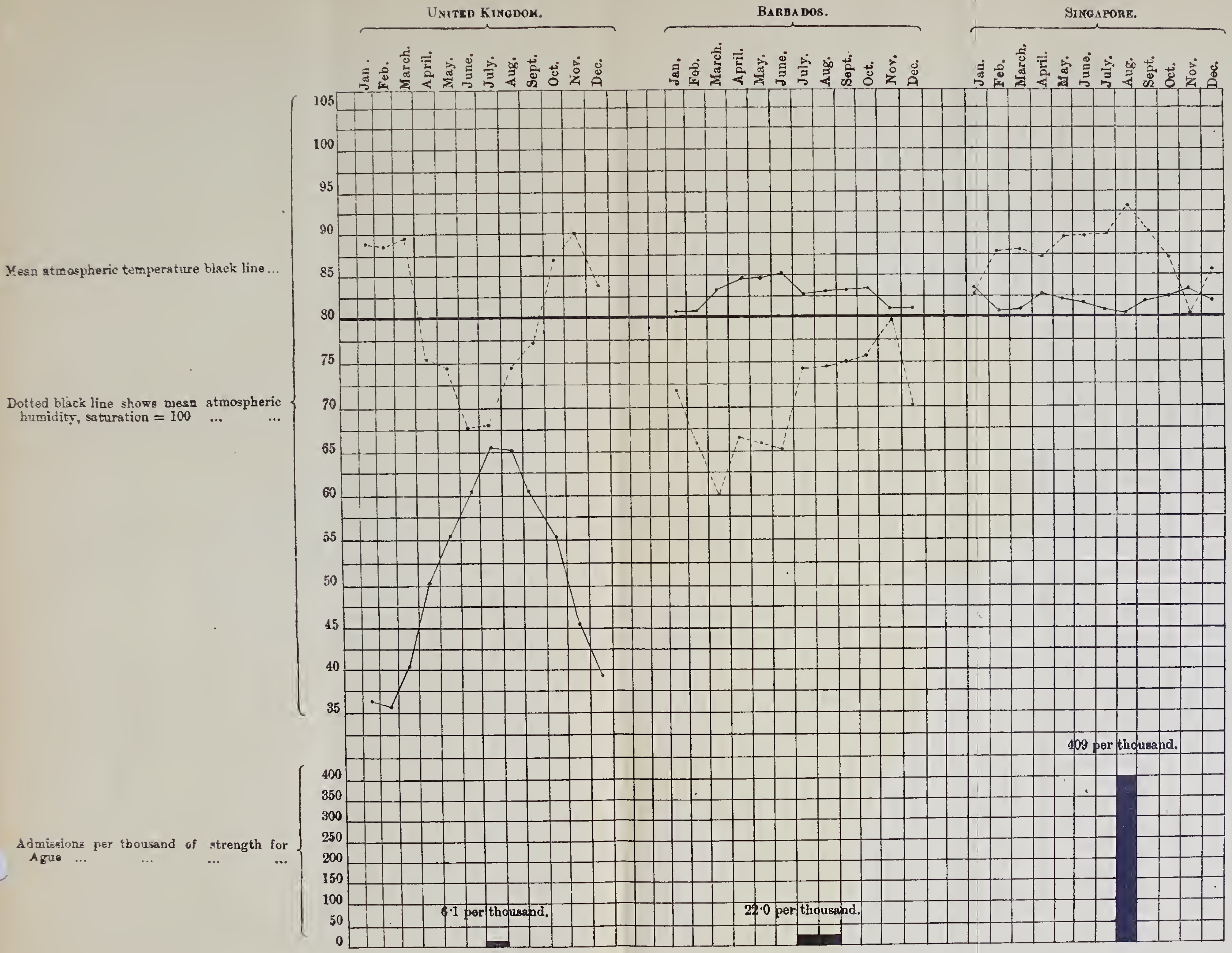
Atmospheric temperature.—The degree of atmospheric temperature under which Ague tends to become most prevalent, can be easily seen from the Reports of the Army Medical Department.

If we take for instance nine stations throughout the world, say England, Gibraltar, Malta, Bermuda, Barbados, Sierra Leone, Singapore, Hongkong and India, and examine their meteorological records and statistics of Ague, it is apparent that where Ague is prevalent the monthly mean temperature of air is F.80° or higher during those months of the year when this disease prevails. At the same time, it is seen that Ague may not be prevalent in some stations, such as Barbados, where the atmospheric temperature is over F.80° for nearly the whole year.

This, however, instead of proving to be a difficulty, will be found to be a considerable help in demonstrating the environment under which Ague prevails.

This environment evidently consists of something more than high atmospheric temperature. What is it?

Atmospheric humidity.—If the meteorological records for the same stations are examined as regards humidity, it is apparent that where Ague is prevalent the monthly mean atmospheric humidity is 80% of saturation or higher, during those months of the year when the disease prevails. At the same time it is seen that Ague is not prevalent in stations such as England where monthly mean atmospheric humidity is 80% or higher for six months of the year. From these records it is apparent that although Ague may not be prevalent where there is merely high atmospheric temperature *or* high atmospheric humidity, it is invariably prevalent where *both* temperature and humidity are high. This will perhaps be more easily seen from the accompanying chart. From it can be seen that in *England* although humidity of air is high for a considerable portion of the year Ague does not prevail. The absent factor is high atmospheric temperature.


UNITED KINGDOM.
BARBADOS.
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105
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95
90
85
80
75
70
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60
55
50
45
40
35
Mean atmospheric temperature black line ...
Dotted black line shows mean atmospheric humidity, saturation = 100 ... ...
Admissions per thousand of strength for Ague ... ...
400
350
300
250
200
150
100
50
0
6·1 per thousand.
22·0 per thousand.
409 per thousand.

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In *Barbados*, although temperature is high for the whole year, Ague does not prevail. The absent factor is high atmospheric humidity.

In *Singapore* both temperature and humidity are high for nearly the whole year, and Ague is very prevalent.

This only shews more clearly what has been so long known, *viz.*, that the environment under which Ague becomes most prevalent is a hot, moist, stagnant atmosphere. This indeed is not only apparent as regards *climates*, but also as regards *seasons* of the year and *localities*.

For example, as may be seen in the Reports of the Sanitary Commissioner with the Government of India, in the months, July, August, September and October, when Ague is most prevalent, the mean atmospheric temperature is F.80° or higher, and the mean atmospheric humidity is over 80% of saturation. Whereas in the months of December, January and February, when Ague is least prevalent, the mean atmospheric temperature is under F.70°, and the mean atmospheric humidity is under 70% of saturation. Here, again, we see that the environment under which Ague becomes most prevalent is the hot, moist, stagnant atmosphere. But even *within* malarial climates and season's experience teaches us that there are certain *localities* such as the low-lying swamp, dense jungle and deep ravine, where the disease is much more prevalent than on the elevated and open situations. But the low-lying swamp, deep ravine and dense jungle are obviously the localities in which the atmospheric temperature and humidity are highest. In such places the environment closely resembles the atmosphere in a Russian vapour bath, and is hot, moist and stagnant.

This, then, being the environment under which Ague becomes most prevalent, I will next endeavour to make clear how it produces an Intermittent Fever or Ague.

II.—CAN ENVIRONMENT CAUSE AGUE?

—:o:—

The answer to the above question must, I think, be in the affirmative for the following reasons:—

1*st.*—The Meteorological environment under which Ague becomes most prevalent is a hot, moist, stagnant atmosphere.

2*nd.*—Exposure to this malarial environment produces an intermittent increase of water in the blood.

3*rd.*—Intermittent increase of water in the blood produces an intermittent fever.

4*th.*—Elimination of water from the blood, in Ague reduces temperature to normal.

5*th.*—Increase of water in the blood plus the increase of temperature in Ague produces (*a*) wholesale destruction of red blood corpuscles; (*b*) increase of pigment, free or enclosed in bodies of various shapes, melanæmia; and (*c*) enlargement of the spleen.

By *environment* in this case I mean the hot, moist, stagnant atmosphere which prevails in those climates, seasons, localities, and even periods of the day, in which Ague is known to be most certainly contracted.

Of course it will be at once objected that as Ague occurs sometimes in any and every climate, this cannot possibly be the cause of the disease. But I would point out in the first place that climates, at all events as regards their atmospheric temperature and humidity, differ only in degree; and that a lower degree of this influence may produce the same effect on one individual as a much higher degree will produce on another. And in the next place I will point out a definite and appreciable condition of the blood which will make clear why some individuals should be more, and some less, susceptible to this influence. In other words why some should not contract Ague in the most malarial climates, and why others do so in climates not considered malarial.

Now, that the environment of a hot, moist, stagnant atmosphere distinctly tends to increase the body-temperature, is not only generally believed but is capable of actual proof.

For example, Frey and Heiligenthal experimenting with different kinds of air-baths accurately determined the effects of exposure of the body to increased temperature and increased humidity of the atmosphere.

By exposure in a Turkish or hot *dry* air-bath to a temperature of F. 149° for fifty minutes the temperature of the body was only raised to F. 101·6°. On the other hand, exposure in a Russian or hot *vapour* bath of only F. 113° for only twenty-five minutes raised the body-temperature to F. 104·3°.

The explanation of this is obvious. In the hot *dry* atmosphere of the Turkish bath evaporation from the skin and lungs is greatly increased and this keeps the body-temperature under control. In the hot *moist* atmosphere of the Russian bath evaporation from the skin and lungs is impeded if not arrested. The natural cooling function of the skin being thus arrested, the body-temperature must of course rise as it does in the vapour bath.

But besides impeding evaporation from the skin and lungs, exposure in the hot *vapour* bath also reduces excretion of water from the kidneys. It must therefore produce *accumulation of water* in the blood. The two most obvious effects of exposure in a Russian or hot *vapour* are then—

(1*st*) increase of water in the blood ;
(2*nd*) increase of temperature of the body.

On leaving the hot vapour bath, the temperature of the body falls to normal in a few minutes.

Bearing in mind the above results of exposure in the hot, moist, stagnant atmosphere of a Russian *vapour* bath, it is evident how exposure to the hot, moist, stagnant atmosphere of malarial climates will as certainly, if not so rapidly, produce the same effects. For such environment differs only in degree from that of the Russian *vapour* bath of F.113° which raised the body-temperature to F.104·3° in twenty-five minutes.

Now, with regard to the first effect of exposure to such environment, it may be asked is there, as a matter of fact, increase of water in the blood in Ague? Liebermeister seems to have established this, for he declares that the wasting of the body in Ague is sometimes concealed by the excessive amount of *water* contained in the blood and tissues. From this cause the weight of the body may be increased as much as 10℔s., although there may be only slight œdema of the ankles to indicate an excess of water in the blood and tissues (Fagge, Vol. I, p. 48).

Now what is the effect of increase of *water* in the blood? Physiologists tell us that it increases metabolism, that is, heat production. And Payne tells us that injection of *water* into the blood causes a rise of temperature (General Pathology, p. 144).

Above I have first shewn, by example of Frey and Heiligenthal's experiments with the Russian *vapour* bath that exposure to a hot, moist, stagnant atmosphere produces an increase of water in the blood and fever. I have then pointed out that there is known to be increase of water in the blood in Ague (Liebermeister). And lastly, that increase of water in the blood produces fever (Payne).

It is now necessary to show that the increase of water in the blood, produced by exposure to the hot, moist, stagnant atmosphere of malarial climates, must be intermittent. To make this evident it only remains to point out that the environment, which causes it, is of intermittent intensity, for, we know that in all climates atmospheric humidity and temperature undergo a daily variation. The highest atmospheric temperature is registered about 4 o'clock P.M. daily, and the lowest about 4 o'clock A.M. The highest atmospheric humidity is registered about 4 o'clock A.M. daily, and the lowest about 4 o'clock P.M. That is, in malarial climates the environment which produces increase of water in the blood is of greater intensity in the early morning, and of less intensity in the afternoon. And if the cause is of intermittent intensity the result will also be intermittent in character, and the increase of water in the blood will therefore also be intermittent. As it is the increase of water in the blood that causes the rise of temperature the type of fever caused by it will of course be intermittent too, as we know it to be in Ague.

Now, in the commencement of this paper, I said that I would point out a definite and appreciable condition of blood which would explain the varying susceptibility of individuals to the disease. Moreover, it will explain why the type of fever is quotidian in some and in others tertian or quartan. It also affords an explanation why tertian and quartan types are those usually found in temperate climates, and quotidian the type usually found in tropical climates. It also affords a rational explanation why some individuals never contract the disease, or, in other words, exhibit immunity.

This definite or appreciable condition of blood is the quantity of water contained in the blood of each individual.

We know that in health the quantity of water in the blood may vary within certain limits, and that average blood contains about 790 parts in 1000 parts.

It will of course require exposure to the environment for some time more or less before the quantity of water in the blood is increased to that degree which causes fever. Let us suppose that the degree necessary to cause fever is 830 parts in 1000.

If four men whose blood contains respectively 790, 800, 810 and 820 parts of water in 1000 be exposed to the environment which produces excess of water in the blood, it is evident that the increase of water necessary to cause fever will be most rapidly produced in the man whose blood originally contained most water or was poorest. It only requires 10 parts added to it. This accords with experience which teaches that those with the poorest or most watery blood most quickly contract Ague when exposed to the environment.

It will take proportionally longer in the others to produce the 830 parts of water, the man whose blood was in the first instance normal (790 parts water) requiring the longest exposure.

Again, let us suppose that the degree of intensity of the environment to which they are exposed produces an increase of water in the blood equal to 10 parts daily. Then it is evident that the blood of the man containing originally 820 parts of water, will have its water increased to the necessary 830 parts by *one* day's exposure. And although critical elimination (sweat) reduces it to the original 820 parts, if exposure to the environment continues 10 parts will be added again next day, producing the necessary 830 parts of water increased metabolism and fever. That is the degree of hydræmia which causes the fever is reproduced daily and the type of Ague is therefore *quotidian.*

At the same rate of 10 parts daily it will require *one day longer* exposure to produce 830 parts of water in the blood of the man originally containing only 810 parts of water ; and after elimination (sweat) it will take one day longer to reproduce, that is, instead of being reproduced daily, it will only be reproduced every *second* day. There will be one day of apyrexia. The type of Ague will be *tertian.*

Similarly at an increase of 10 parts daily it will require an exposure of *two days longer* to increase the amount of water in the blood of the man containing originally 800 parts of water, to the necessary 830 parts to cause fever, and after elimination (sweat) it will take *two days longer* to reproduce. That is, there will be *two days* of apyrexia and the type will be *quartan* Ague.

In the blood of the man containing originally 790 parts of water it will take still longer exposure to produce. and after elimination to reproduce, the necessary 830 parts of water. And in those with originally still less water in the blood, and whose excretory organs are perfect it is conceivable that the necessary increase to 830 parts of water cannot be produced by any exposure, and in such cases we should expect immunity from the disease.

It can be seen then, if Ague is due to excess of water in the blood caused by environment, why the type of disease should be quotidian in some, tertian in others, and quartan in others ; and also why those with the poorest or most watery condition of the blood should most certainly contract the disease, whilst those with less water in their blood should be less liable to contract it.

In addition, if Ague is due to excess of water in the blood, it is evident why quotidian is the most common form of Ague in tropical climates and tertian, or quartan forms the most common in temperate climates. For in tropical climates the environment (temperature and humidity) is of a higher degree of intensity, and in temperate climates lower. Hence in tropical climates the degree of hydræmia that causes fever will be more quickly produced and after elimination reproduced ; that is, the type of Ague most commonly met with will be that with the shortest period of apyrexia, *viz.*, quotidian. In temperate climates the environment, not being so intense, will of course take longer to produce and, after elimination, to reproduce the degree of hydræmia that causes fever ; that is, in temperate climates the type of Ague most commonly met with will be that with a longer period of apyrexia, *viz.*, tertian or quartan.

Moreover, as the amount of water in the blood depends to a great extent on the balance being maintained between the amount excreted and the amount taken in ; and as the amount excreted depends to a great extent on the healthy performance of their functions by certain organs, skin, kidneys, &c., it can be seen how deranged or defective function of such organs might produce the increase of water in the blood that causes fever altogether independently of external environment. By such derangement I would explain those anomalous cases of Ague which occur in climates, seasons or localities where the hot, moist, stagnant atmosphere, the environment of Ague, is not found.

Again we know that free elimination of water from the blood in Ague reduces temperature to normal. Free sweating obviously does so. This fact of itself is strong presumptive evidence that the disease is due to excess of water in the blood, for there are many other fevers in which free sweating does not produce this effect. Moreover, although sweating is the natural method of termination of a paroxysm of Ague, the same result may be produced by free elimination of water through the kidneys or by purging. These two latter processes, however, only reduce the amount of water in the blood and so reduce heat production, whilst sweating besides reducing the amount of water in the blood (heat production) also increases evaporation from the skin (heat loss) and thus more quickly reduces temperature to normal.

It may be said that because free sweating induced before an expected paroxysm of Ague, does not prevent the body-temperature from rising, the disease cannot be due to excess of water in the blood. But free sweating, or what appears to be free sweating, does not prevent the body-temperature rising in the Russian vapour bath. The fact is, that although sweat appears on the skin in such cases it is not because it is excreted in larger quantity, but that, the environment being saturated with moisture, evaporation is impossible or at all events much impeded. Hence the sweat accumulates on the skin.

Now if there is increase of water in the blood in Ague, there are present during each paroxysm of the disease two influences which profoundly alter the blood corpuscles. These are *increase of water* produced by environment, and *increase of temperature*, that occurs during each paroxysm, which may amount to as much as F.110° or higher in the deep parts, such as within the portal circulation. What is the effect of such influences on the appearance of the blood corpuscles?

In answering this question I will place side by side in parallel columns a description as given by Physiologists of the changes produced in blood corpuscles by exposure to the influence of increase of water, and increase of temperature ; and a description of the appearances of malarial parasites as given by plasmodists.

Physiologists tell us.	*Plasmodists tell us.*
1. If *water* be added to normal blood, the red corpuscles lose their discoid form, become spherical, swollen, and *dropsical*, the hæmoglobin is washed out of them, and ultimately they disintegrate and disappear.	1. The red corpuscles attacked by the malarial parasite are usually the larger ones. They lose their disc-like shape and become spherical, swollen and *dropsical*, they lose their colour and ultimately disappear.
2. If blood be *heated*, vacuoles are produced in the red corpuscles which appear as little clear, colourless shining spots that assume spherical, annular or other forms, they change their form, they increase in size till they occupy half, two-thirds, or the whole of a corpuscle. They exhibit amœboid movement from contractions in the surrounding hæmoglobin, and they throw out little fine headed prolongations which wave to and fro. There may be one or more vacuoles in each corpuscle.	2. Malarial parasites appear in the first instance on, or in, the red corpuscles as little clear colourless shining spots of various forms, spherical, annular or other. They change their form. They increase in size until they occupy most or the whole of the corpuscle. They exhibit amœboid movement, and throw out flagella. There may be one or more parasites in each corpuscle.
3. If water is added to normal blood *and* the specimen heated a few degrees above normal, the white blood corpuscles which may or may not contain pigment exhibit active amœboid movement, and	3. The larger spherical pigmented parasites exhibit active amœboid movement, and their contained pigment exhibits active swarming movement.

Brownian movement of the contained pigment.	
4. The result of increase of water in the blood and exposure to increase of temperature is destruction of red corpuscles and production of pigment free and enclosed in spherical or various shaped bodies.	4. The result of invasion of the red corpuscles by the parasites is wholesale destruction of the corpuscles and increase of pigment in the blood free and enclosed in spheres, crescents, &c.

Mannaberg and others distinguish the small spherical parasites from the vacuoles in red corpuscles by their relative brilliancy and relative sharpness of contour before they become quiescent.

When we remember the infinitely minute size of these bodies, the difficulty of deciding on their relative brilliancy and relative sharpness of contour while in motion, is apparent. Indeed Mannaberg evidently feels that his method of distinguishing them is not very convincing, for, he adds apologetically, that the differences are difficult to describe shortly in words, but, by a little experience, it is possible in the majority of cases to decide one way or the other.

In the first place, I cannot understand why it is so difficult to describe shortly in words what experience enables him to accomplish so easily in practice, and he does not tell us how experience enables him to distinguish parasites from vacuoles except as above given.

As regards distinguishing the larger spherical pigmented parasite from a pigment bearing leucocyte, Laveran depended on the fact that the leucocyte exhibited a nucleus and the parasite did not. This was definite at all events. Mannaberg and others, however, declared that the parasites have a nucleus, thus proving them to be living organised beings, and thus destroying Laveran's distinguishing mark. Of course the leucocytes, as they present a nucleus, must also be living organised beings. Plasmodists declare, however, that they can distinguish these nuclei.

With regard to crescent-shaped parasites plasmodists seem not to be agreed as to whether their transformation into spheres and flagellation is a developmental process providing for the continuation of the species or a sign of degeneration and death.

Ross, after many beautiful experiments, is of opinion that the transformation is developmental, and that the influence which produces the transformation or perhaps allows it, is *abstraction of water* from the serum. This he concludes is the influence to which the crescent is exposed within the stomach of the mosquitos.

But Ross had no sooner come to this conclusion than he saw that *Marshall*, also as the result of experiments, had come to a diametrically opposite conclusion, *viz.*, that the influence which causes transformation is the *addition of water*, and that this may take place within the stomach of the mosquito !

Ross tries to reconcile these very widely diverging views by saying that transformation of crescents is promoted by both increased and decreased density of the serum in which they float.

But whether it is or not I would call attention to the facts, 1*st*, that they both apparently recognise and admit the influence which *variation in the amount of water in the serum* exercises in the production of some at least (crescents, flagella and spheres) of the bodies described as parasites; and 2*nd*, that *variation in the amount of water in the serum*, produced by environment, is the pathological condition which I maintain exists in Ague.

During the paroxysm there is increase of water in the serum. Here is the condition which Marshall holds, converts crescents into spheres, &c. After the sweating there is obviously reduction of water in the serum. Here is the condition which Ross maintains, transforms crescents into spheres, &c.

How increase of water in the blood produces melanæmia or increase of pigment in the blood and tissues may be seen by reference to the lectures of Professor W. Hunter on Blood Destruction in the *Lancet* of 26th November 1892. He says the causes of hæmolysis or blood destruction are two, *viz.*, direct and indirect. The first consists of agents which injected into the blood act directly on the blood, *such as water, &c.* The second acts indirectly through the splenic cells. He then says that the hæmolysis of disease is similar to that produced by indirect hæmolytics with two exceptions, namely, hæmoglobinurea and malaria which he attributes to the direct action of parasites on the red discs. But, if there is increase of water in the blood in Ague, as I maintain in this paper, there is increase of an agent that Hunter has shewn to a most powerful direct hæmolytic.

So that whether Laveran's bodies be parasites or not, there is quite sufficient to explain the occurrence of wholesale destruction of red blood corpuscles and the presence of pigment free and enclosed in spheres, &c., in Ague. Hunter describes, during the progress of hæmolysis produced by injection of water into the blood, the appearance in the blood especially within the portal circulation of the following :—

1*st.*—*Colourless spherules*, albumenous, and highly refractile of varying size.

2*nd.*—*Coloured spherules.* A red corpuscle becomes constricted at some portion dividing into two parts connected by a colourless portion. These are best studied by warming blood to C.45° (a temperature not much above portal blood in a paroxysm of Ague) when the corpuscle breaks up into a number of highly coloured spherules. This description of the disintegration of a blood corpuscle produced by a temperature of C.45° plus addition of water, reminds one of the description of sporulation of parasites, said by plasmodists to occur during each paroxysm of Ague.

3*rd.*—Stromata decolorised red corpuscles best studied by injection into the blood of *distilled water.*

With regard to Hunter's statement that blood destruction and production of various shaped bodies and pigment takes place chiefly within the portal circulation, I would draw attention to the fact that plasmodists say when parasites cannot be found in the general circulation they can certainly be found within the portal circulation.

From what has been written above it can be seen that if Ague is due to increase of water in the blood there must be (*a*) wholesale destruction of red blood corpuscles ; and (*b*) melanæmia. And during each paroxysm of the disease the following will be produced in the blood :—

1*st.*—Red corpuscles which have become enlarged, spherical and *dropsical.*

2*nd.*—*Vacuoles* in the red corpuscles exhibiting amœboid movement and throwing out fine headed prolongations which move to and fro.

3*rd.*—*Spherical pigmented bodies* exhibiting amœboid movement and Brownian movement of the contained pigment.

4*th.*—*Colourless Spherules*, albumenous and highly refractile.

5*th.*—*Coloured Spherules*, joined by a colourless portion, which disintegrate into a number of highly coloured spherules.

6*th.*—*Stromata.*

7*th.*—*Pigment* free and enclosed in various shaped bodies.

It is evident then if Ague is due to increase of water in the blood that many bodies will be found in the blood during each paroxysm and after, in addition to the normal unaltered corpuscles.

It next remains to be seen if intermittent increase of water in the blood will cause enlargement of the spleen. It probably must do so. For increase of water of course means increase of volume of the blood from which, the spleen, being so vascular and elastic, yields and becomes enlarged. Whether it is due to this cause or not we know as a matter of fact that the spleen does enlarge during each paroxysm, but at first returns to its normal size during the periods of apyrexia.

Thus there is intermittent enlargement of the spleen at first. This if continued must eventually produce permanent enlargement of the organ, Ague Cake. For, as Payne points out, hypertrophy of an organ is more likely to occur from transitory but repeated hyperæmia than from simple hyperæmia continued for some time.

Further argument in favour of this theory of the disease may be adduced from the fact that all effective treatment of Ague reduces the amount of water in the blood. Diaphoretics and purgatives obviously do so. So does quinine as I think any one will admit who has taken it in any quantity. And when the chronic stage is reached what is so beneficial as a course of Turkish or hot dry air-baths when available. Arsenic also reduces the amount of water in the blood, and massage also promotes its reduction. And when we treat enlargement of the spleen by counter-irritation and administration internally of quinine and iron, do we not always find it necessary to add saline purgatives.

Change of climate is indeed the best of all remedies for Ague, and what is change of climate but change of the environment that produces increase of water in the blood ?

Now, as regards prevention of Ague, drainage of the soil eradicates the disease. The most obvious effect of drainage of the soil is that it dries the soil and therefore dries the superincumbent atmosphere. For humidity of the atmosphere is due chiefly to evaporation of water from the soil. Drainage of the soil therefore reduces one factor, atmospheric humidity, of the malarial environment, in the absence of which the disease never becomes prevalent. It thus obviously alters the environment which produces increase of water in the blood. And experience teaches that no measure can compare with it in value for eradication of Ague from paludal districts.

While I hold that Ague or Intermittent Fever is caused by environment, it should be understood that I do not hold that remittent, continued or other form of malarial fever is due to this cause.

To give expression to views, which in any way seem to throw doubt on the parasitic origin of malaria, requires, in these days, a certain amount of moral courage, for any one who does so is quickly denounced as unscientific and retrogressive.

Still a change in this respect seems to be foreshadowed by Mr. Malcolm Morris in his article on the progress of medicine during the Queen's reign, in the *Nineteenth Century* for May. He says : " Indeed the doctrine that every disease is a kind of fermentation caused by a micro-organism is so fascinating that it is in danger of being treated as if it were a master key which unlocks all the secret chambers of pathology ; it is becoming clear however that, if microbes are necessary causes of a large number of diseases, they are sufficient causes of very few. The living body, and its environment, must be taken into account. Hence there are signs in various quarters of a reaction against the exaggerated cult of the microbe, and some of the most advanced investigators are turning once more to cellular pathology which, till quite recently, was spoken of as a creed outworn."

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